# BOTANY.—*The ecology of the wild kidney bean* Phaseolus polystachios (*L.*) *BSP.*[1]

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In view of the great value of beans as a human food crop all over the world, and the increasing interest in the genetics of the various members of the group in problems of breeding for disease resistance and insect tolerance, and increased productivity and climatic adaptation, it seems advisable to bring together all our knowledge of the wild bean of the eastern United States so far as possible.

According to Small (1913) three species of *Phaseolus* occur in the eastern United States, *P. sinuatus* Nutt., *P. smilacifolius* Pollard, and *P. polystachios* (L.) BSP. The first two species are Florida or Gulf coast species, occurring in dry pinelands and hammocks. *P. polystachios* extends from Florida northward to Canada and Minnesota and westward into Louisiana and Nebraska. I know nothing of the behaviors and relationships of *P. sinuatus* or *P. smilacifolius*, whether the cotyledons are epigean as in the case of the beans of *P. vulgaris*, or hypogean as is the behavior of *P. polystachios*, as established by Harry A. and Howard F. Allard (1940). This would be a very interesting point to consider, however, in determining the relationships of these southern species.

Following are the distinguishing botanical characters of *Phaseolus polystachios:*

A twining, finely pubescent, herbaceous perennial with tuberous root; leaves 3-foliolate, the leaflets roundish-ovate; flowers in numerous peduncled, loosely flowered racemes, 4 to 10 inches long or more, purplish-blue, small, showy, produced from midsummer till fall; style bearded lengthwise on the upper surface; keel spirally coiled; pods somewhat curved, drooping, 2.5–5.0 cm long, 5–8 mm wide; beans 4 or 5, round reniform, 3–5 mm long, dark brown, finely speckled with black; cotyledons hypogean. A plant of thickets and woodlands on the Coastal Plain and in the Piedmont area.

## HABITAT RELATIONS OF PHASEOLUS POLYSTACHIOS

*Phaseolus polystachios* is a thicket and woodland plant in its natural habitat and can not compete with grassland or the broomsedge habitat of open fields and pastures. Even if it were adapted to such open conditions, the trampling and browsing of stock would probably lead to its ultimate extermination here, for it is a delicate climbing plant. In northeastern Virginia, I have found it scattered over the steep rocky slopes of Bull Run Mountain, but it is far from common here. In truth I have never found it common anywhere in its range. In the Bull Run area it is usually found on the warmer more protected east slopes. It is much more common on the wooded slopes of the granitic knobs of Big Cobbler, Rattlesnake, and Oventop, all outliers of the Blue Ridge Province. I have never found it on the higher ridges of the Blue Ridge or the Alleghenies.

According to Small and Carter (1913) it occurs on sandstones, shales, and schists in Lancaster County, Pa. In the Bull Run area it occurs on the drier ridges of the Cambrian quartzites, which in weathering produce a sterile, porous, sandy type of soil. I have never quite understood the restricted distribution of this plant on the Bull Run ridges and its strong predilection for the upper slopes just below the outcropping, steeply tilted sandstone ledges. This relation holds throughout the length of these north-south ridges. One ecological relationship is very pronounced, however: this bean does not tolerate anywhere heavy, wet soils or heavy shade. The soils of the upper slopes of the ridges are not only drier, thinner, and always thoroughly drained, but the character of the forest is more open here, and better illumination obtains from the fact that it is dominated by a less vigorous stand of chestnut oaks. This combination of favorable factors may be responsible for the establishment of the wild bean in this particular zone. In favorable woodland situations there is a noticeable tendency for the plants to occur in colonies. This is due to the fact that when a perennial rootstock has become established the seeds produced tend to fall near the parent plant, and the germination of these year after year favors the development of colonies.

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These colonies gradually enlarge as the seeds from the twining, scrambling aerial stems of the peripheral plants reach more outlying areas.

Although in Gray's *Manual* (1908) the characterization of the genus *Phaseolus* states that the fleshy cotyledons rise out of the ground nearly unchanged in germination, L. H. Bailey (1935, p. 458) says that the bean differs from the pea in being epigeal in germination that is pushing the cotyledons above the ground. I have found that this is not true for the wild kidney bean. As previously stated the cotyledons have an hypogean existence, as in the case of the cultivated Scarlet Runner bean *Phaseolus multiflorus* Willd.

Under favorable woodland conditions where there is an abundant, protective, loose, forest litter and a layer of rich leaf mold, the wild bean becomes perennial, and develops a large, tough rootstock very deeply rooted in the loose, porous soil. This rootstock may become an inch or more in diameter at the crown and produces here many buds at the leaf-mold level. Some of these rootstocks appear to have survived for many years, and thick fleshy roots have penetrated the soil for 15 to 18 inches. The wild bean grows vigorously in well-drained garden soil, but owing to the wet, soggy condition of such soil in winter, the rootstocks do not well survive the winter here.

The wild bean is a tuber-producing plant, storing up an abundance of reserve material in good-sized spindle-shaped tubers, only a portion of which is used in the annual formation of the slender aerial stems. I did not realize that tuber formation was such a pronounced characteristic of this species until I had occasion to dig up some rootstocks in the spring of 1947 in the Bull Run Mountain area. In this respect, as in the hypogean behavior of the cotyledons, the wild bean shows closer affinities with the Scarlet Runner assemblage, *Phaseolus multiflorus*, than with the common field and snap beans *Phaseolus vulgaris* L.

### LENGTH-OF-DAY BEHAVIOR

I have studied the length-of-day behavior of the wild bean rather fully, both in localization experiments and on various lengths of day (Allard, 1938). In the localization tests one stem of a rootstock was kept under short-day conditions of 10 hours (from 6:00 A.M. to 4:00 P.M.) each day, while another stem from the same plant was exposed to the full day of Washington, D. C. The average length of day from March 21 to September 21, through the longest days of the summer solstice (near 15 hours from sunrise to sunset), is about 13 hours, and from April 15 to September 2 the length of day exceeds 13 hours. The stem given only 10 hours of light each day grew but little beyond the original height, 5 inches, when the tests began, and finally died late in summer without budding. The outside stem experiencing the full day grew very vigorously as a climber, attaining a height of 3–4 feet; buds appeared on July 21 and flowers August 2. This portion of the plant was very floriferous and produced many pods (Allard, 1938a, fig. 2).

Further photoperiodic studies were made subjecting the entire plant to constant lengths of day with a series of lengths of day arranged as follows: 10, 12, 12½, 13, 13½, 14, 14½ hours, and full day. These tests demonstrated that flowering was most prolific on intermediate lengths of day from 13½ hours through 14 hours, 14½ hours, and the full length of day.

Plants receiving only 10 hours of daylight each day never flowered. One flower only appeared on the plants afforded 12 hours of daylight. Flowering was more vigorous with 13 hours of daylight each day, but some of the blossoms even here were cleistogamous.

The twining habit did not develop until the plants were afforded 13½ hours of daylight but remained low, bushy, and dark green. On lengths of day shorter than 12½ hours the plants showed the dwarfed, sterile, winter behavior, with thickish, dark-green, rugose leaves and short thickened stems. These plants barely survived the summer and remained practically in a state of vegetative dormancy for many months.

The normal twining habit of the wild bean is entirely dependent upon length of day, and this response does not become evident until a length of day between 13½

and 14 hours is experienced. Until a vigorous twining habit has developed the plants produce few flowers. Vigorous flowering is not strictly correlated with the twining habit, however, since an excessively long day of 16-18 hours, obtained by artificial light, again tends to inhibit flowering, although a vigorous twining behavior is maintained. These relations are clearly shown by Allard (1938a, fig. 5). In figure 6 (Allard, 1938a) the growth of plants is shown under 12 hours and 12½ hours of light daily. The 12-hour plants never flowered, but one plant of the 12½-hour group flowered on July 27. The plants in both groups were low and bushy, with the exception of one plant experiencing 12½ hours of light daily, which produced a short runner. As a matter of fact the plants were exceptionally bushy in habit of growth under these shorter-day lengths. The pods and seeds on the 12½ hour plants were exceptionally large for the species, however, some of the pods measuring 5.8 cm in length from the tip of the beak to the calyx, with a maximum width of 11 mm.

It is evident that the wild bean is a long-day type of plant, i.e., it flowers on a lengthening day. Lengths of day below 12½ hours not only inhibit twining, so that the plants become low and bushy, but also prevent flowering. Such plants behave as if they were in a more or less quiescent or dormant condition. This short-day behavior limiting flowering and seed production would exclude this bean from the Tropics and adapt it to more northern latitudes, until cold and perhaps excessively long days became the limiting factors governing its survival.

This bean is probably a northern derivative of the more southern bean assemblage, for in its present form it could not have originated in the Tropics, nor could it survive there with its present characteristics of behavior.

Stem elongation or twining behavior is an interesting growth response in relation to length of day, and whether induced by long or by short photoperiods, depends entirely upon the species. The wild bean *P. polystachios* becomes bushy as the days are shortened. The Jack bean, *Canavalia ensiformis* (L.)DC., becomes a pronounced twiner on the same short days that produce dwarfed plants in the wild bean. The wild bean becomes a climber on an increasing length of day, while the Jack bean becomes bushy on a lengthening day. The common garden beans, *P. vulgaris*, and *Stizolobium deeringianum* Bort., as in the case of the wild bean, completely reverse these length-of-day relations of *Canavalia*, but greenness of the leaves is not noticeably changed. (Allard and Zaumeyer, 1944.)

Allard and Garner (1940) have shown that the Medellin bean, F. P. I. No. 46145 *Phaseolus coccineus* L. (*P. multiflorus*), flowered best on short days, with a remarkable enlargment of roots to produce tubers when the plants experienced photoperiods of 10 hours. This flowering behavior shows that this particular bean is eminently adapted to the short tropical days.

Some strains and varieties of tropical beans are not only short-day plants in their flowering responses but show marked tendencies to produce pronounced underground tubers under short-day conditions. This behavior was shown in the case of a tropical South American bean (*Phaseolus multiflorus*). Plants exposed to 10 hours of daylight throughout the summer, and to the shorter winter days in the warm greenhouse, became strongly tuberized (Garner and Allard, 1923, p. 893, pl. 6). Other plants of this bean exposed to the full day of summer, and to electric light during the winter in the greenhouse to extend the length of the natural day, never flowered and never produced tubers. Twelve hours of light in summer and the natural winter length of day produced less tendency to tuberize than the 10-hour plants. Tuberization of these tropical beans appears to be a response to the short days, just as in the case of the wild bean. In the latter, tuberization appears to take place on the shortening days of late summer and autumn.

### CHROMOSOME NUMBER OF PHASEOLUS POLYSTACHIOS

Eleven species of beans of the genus *Phaseolus* are known to be more or less generally grown in various parts of the world. As reported by J. Kamakami (1930), all these have 22 chromosomes as the *2n*

number. Among these are *Phaseolus acutifolius, P. angularis, P. aureus, P. coccineus, P. lunatus,* and *P. mungo. Dolichos lablab* has 22 (*2n*) chromosomes.

The chromosome number of the wild bean was determined by Howard F. Allard (1940), and the *n* number of the pollen mother cells was found to be 11; the somatic (*2n*) number, then, is 22, as in all other species of *Phaseolus* reported upon. These chromosomes are of small size in the wild bean. It would appear that from the constancy of chromosome number in the genus *Phaseolus,* the genus is rather stable in this respect, or perhaps of more recent evolution. The genus as a whole appears to be of tropical and warm climate origin, since the center of distribution is within the Tropics. Such species and varieties as are now grown in higher extratropical latitudes are either day-neutral sorts or those with high critical limitations with respect to length of day which favors flowering in high latitudes.

### ENEMIES

The wild bean may flower profusely, but often very few pods are found on the flowering panicles. In the green state a tiny native weevil rather freely parasitizes the pods. In my garden it seemed to me that the Mexican bean beetles were less inclined to attack this bean, but much more study is needed to establish this relationship fully.

As a food plant the beans are too small to be of any value to human beings, and there is no evidence that even the eastern Indians ever made use of this bean, owing to its scarcity. The weight of 100 mature beans harvested in the Bull Run Mountain area was only 6.8 grams.

I am informed by Dr. Volney H. Jones, of the Museum of Anthropology of the University of Michigan, that beans of some race of this species have been found fairly numerous in bluff shelters in the Ozark region of northwestern Arkansas and southern Missouri, and were apparently used for food by the early aborigines. These beans appear to be a larger-seeded race than those of our eastern assemblage, according to Dr. Jones.

It would appear that out wild bean is a plant of considerable interest in many respects—in its various photoperiodic responses, in its taxonomic relationships, and in the possibilities of useful genetic combinations in crosses with some of our useful varieties and species of cultivated beans.

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